Remarks/Arguments

Applicants respectfully request reconsideration of this application in view of the foregoing amendments to the claims and the following comments.

In the Office Action mailed March 8, 2004, all of claims 1-38 were rejected under 35 U.S.C. § 103(a), as allegedly obvious over patent U.S. Patent No. 5,888,592 to Biallas et al. (the "Biallas patent"), in view of U.S. Patent No. 4,143,468 to Novotny (the "Novotny patent"), taken either by itself or in further view of U.S. Patent No. 6,125,549 to Pikus (the "Pikus patent"), U.S. Patent No. 5,856,018 to Chen et al. (the "Chen patent"), or U.S. Patent No. 5,319,861 to Tate (the "Tate patent").

Applicants respectfully traverse the Examiner's rejections. In response to the rejections, Applicants have amended independent claims 1 and 19, to clarify the distinctions of the claimed invention over the cited patents. Applicants also have canceled dependent claims 3, 5-8, 22, and 25-28, without prejudice, and have amended dependent claims 4, 9-12, 21, and 29-37, for consistency with amended independent claims 1 and 19. Amended independent claims 1 and 19, and their remaining dependent claims 2, 4, 9-18, 20, 21, 23, 24, and 29-38, should now be allowed.

The Invention

The present invention resides in an improved apparatus, and related method for using it, to rapidly heat-cure a sol-gel coating adhered to a substrate, without warping or otherwise damaging the substrate. The apparatus includes an IR heating source configured to emit IR radiation in a predetermined pattern and further includes an assembly configured to sequentially expose discrete portions of the coated substrate to the heating pattern at a selected distance and for a selected duration, such that the heat energy from the IR radiation sufficiently cures or densifies the sol gel coating, but does not unduly heat the substrate to cause deformation. At each moment during the cure, only a limited, discrete portion of the coated substrate is exposed to the IR radiation.

In a more detailed, optional feature of the invention, the heating source preferably further includes a second mode for heating the sol-gel coating for densification: hot gas. This transfers heat to the sol-gel layer from both its inside, i.e., the side contacting the plastic substrate, and its outside, i.e., the side exposed to the ambient. In another more detailed feature, optional of the invention, moisture can be introduced into the curing process by injecting steam, or other water forms, into the heated gas stream. In yet another more detailed, optional feature of the invention, the temperature of the heated gas stream is in the range of about 100 to about 500° C, and the flow rate of the heated gas stream is in the range of about 50 to about 10,000 cubic centimeters per second.

Preferably, the coated substrate is sequentially exposed to the heating source at a predetermined speed, e.g., about 0.5 to about 50 centimeters per second. This speed is selected to allow sufficient heat to flow into the sol-gel layer to densify the film and achieve the best optical and mechanical properties.

The invention is particularly beneficial for sol-gel oxide coatings, e.g., SiO_2 and TiO_2, used for optical coatings and for antireflection coatings. The sol-gel coatings themselves can withstand high temperatures, in excess of 500° C. At such high temperatures, a very rapid cure (densification) can be effected. However, for coatings adhered to substrates having a relatively low melting temperature, such high temperatures could damage the substrate. Preferably, the substrate and sol-gel coating are heated using a combination of heating modes to as high a temperature as possible for a short duration of time, providing the required densification of the sol-gel films, but without damaging the substrate. The process can be repeated to produce a product having multiple layers of sol-gel coatings.

The Obviousness Rejections

As mentioned above, all of claims 1-38 were rejected under 35 U.S.C. § 103(a), as allegedly obvious over the Biallas patent in view of the Novotny patent, taken either alone or in combination with the Pikus patent, the Chen patent, or the Tate patent. Applicants

respectfully traverse these rejections. These references fail to disclose an apparatus or method for rapidly heat-curing a sol-gel coating, as defined in these claims.

More particularly, the Biallas patent discloses a laboratory drier for curing a heat-curable industrial lacquer coated onto a substrate. The drier includes two adjacent chambers: a closed irradiation space 1 and a closed convection space 2. In use, the coated substrate initially is transported into the irradiation space, where the *entire* substrate is irradiated by a plurality of IR emitters that provide a desired temperature profile for optimally curing the coating by heat. The coated substrate then is transported into the convection space, where again the *entire* substrate is exposed to drying gases supplied through a plurality of inlet slits 13. Thus, throughout the curing process, the *entire* coated substrate is exposed either to the IR emitters or to the drying gases.

This contrasts with the apparatus and method of Applicants' invention, in which a heat-curable sol-gel coating on a substrate is cured by sequentially exposing only discrete segments of the coating to a heating source. The heat energy provided by the heating source is sufficient to deform the substrate if its exposure time is unlimited, but each discrete segment is exposed to the heating source for only a limited time duration. In this way, the coating is cured without unduly heating the underlying substrate.

The Examiner has acknowledged this deficiency of the Biallas patent: "Biallas et al. does not teach sequentially exposing discrete segments of the coated substrate to the heat pattern." However, the Examiner asserted that this deficiency is addressed by the Novotny patent: "Novotny et al. teaches a similar curing method and apparatus that exposes discrete segments of substrate 10 to radiation from source 50." The Examiner further asserted: "Novotny et al. teaches that exposing discrete segments to heat will prevent damage to the substrate" and, therefore, "it would have been obvious to one of ordinary skill in the art to modify the curing method and apparatus of Biallas et al. with the exposure element and method step of Novotny et al." Applicants respectfully disagree.

Novotny et al. do *not* "teach[] that exposing discrete segments to heat will prevent damage to the substrate." In fact, the Novotny patent is entirely silent on issues of heating and substrate damage. Novotny's curing apparatus exposes discrete portions of a web-like coated substrate to radiation for a purpose entirely unrelated to preventing damage to the substrate. The Novotny apparatus cures the coating by the very different mechanism of ultraviolet ("UV") light, not heat. To cure a UV-curable coating, UV radiation must impinge *directly* on the coating; it is not enough for the coating simply to reside within a space maintained at a particular temperature. To the extent only discrete segments of Novotny's coated web-like substrate are exposed to the incident UV radiation, that is due to the limited size of the UV lamp—it is *not* due to a desire to prevent undue heating of the underlying substrate.

In the Novotny patent, all of the depicted curing apparatus embodiments have lamps that emit UV radiation in divergent beams. No apparent effort is made to limit the beamwidths to a small segment of the substrate. Applicants suspect this is because the UV radiation is of insufficient intensity to unduly heat the substrate.

Thus, the curing apparatus of the Biallas patent is incompatible with that of the Novotny patent. The former cures using IR radiation, whereas the latter cures using UV radiation. Persons skilled in the art, seeking to improve on the performance of the Biallas curing apparatus, would not have looked for clues in the very different Novotny curing apparatus. Moreover, the secondary Pikus, Chen, and Tate patents fail to make up for this deficiency of the Novotny patent.

By this Amendment, Applicants have amended independent claims 1 and 19 to incorporate features previously set forth in dependent claims 3 and 22, respectively. Specifically, independent claim 1 has been amended to specify that the heating source is "configured to emit IR radiation in a predetermined pattern" and to specify that the transfer assembly "is configured to sequentially exposes discrete segments of the coated substrate to the IR radiation . . . such that the heat energy from the IR radiation sufficiently cures or densifies the sol-gel coating, but does not unduly heat the substrate to cause deformation."

Similarly, independent claim 19 has been amended to include a step of sequentially exposing discrete segments of the coated substrate to "an IR heating source at a selected distance and at a selected rate," such that "heat energy from the IR heating source sufficiently cures or densifies the sol-gel coating to its optimum physical and optical properties, but does not unduly heat the substrate to cause deformation."

For the reasons set forth above, it would not have been obvious to have modified the Biallas curing apparatus and method to have substituted an IR heating source that directs IR radiation to only discrete segments of a coated substrate. Accordingly, the rejection of amended independent claims 1 and 19, and their remaining dependent claims 2, 4, 9-18, 20, 21, 23, 24, and 29-38, should now be withdrawn. All of these claims should be allowed.

Entry of Claim Amendments

The amendments to independent claims 1 and 19 do not raise any new issues that will require additional searching or other consideration by the Examiner, because they basically add the same features as previously had been set forth in canceled dependent claims 3 and 22. The claim amendments also present the rejected claims in better form for consideration on appeal. For these reasons, the claim amendments are properly made under 37 C.F.R. § 1.116(b).

Conclusion

This application should now be in condition for a favorable action. Allowance of the claims is respectfully requested. If the Examiner believes that prosecution of the application might be expedited by a telephone conference with Applicants' undersigned representative, she is respectfully requested to call at the telephone number indicated below.

Respectfully submitted,
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